MCEN 5151: FLOW VISUALIZATION
WITH DR. JEAN HERTZBERG

Swimmers, Take Your Mark!

Group Image 3

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Introduction

The intent of this image is to show the startling rebound of a shear thinning liquid, known as the Kaye effect. This image was created with the assistance of teammates Hans Loewenheath and Coulter Pohlman.

Conditions

This image was captured on April 19th at 1:15 p.m., in the Integrated Teaching & Learning Program and Laboratory (ITLL) in the Engineering School at Colorado University at Boulder. We were able to use the vibrations laboratory. Only white light was used, produced by the room's florescent fixtures, augmented with twin 500W Halogen work lamps. A white plastic board was held at a steep angle while the soap was allowed to drop the the spout of an inverted, empty hair conditioner bottle with the bottom cut open (facing the ceiling). The bottle was rigged to maintain a consistent fluid stream location. The board was tilted sharply. The tilt was varied and the board shifted to find the jumping phenomenon. The soap used in this experiment was "Softsoap® Advanced Clean™ Hand Soap with more moisturizer"; The first three ingredients are water, sodium laureth sulfate (detergent and surfactant) and cocamidopropyl betaine (foam booster). Figure 1 shows a mock up of the arrangement for the photograph. The camera was tilted to match the tilt of the white plastic board.

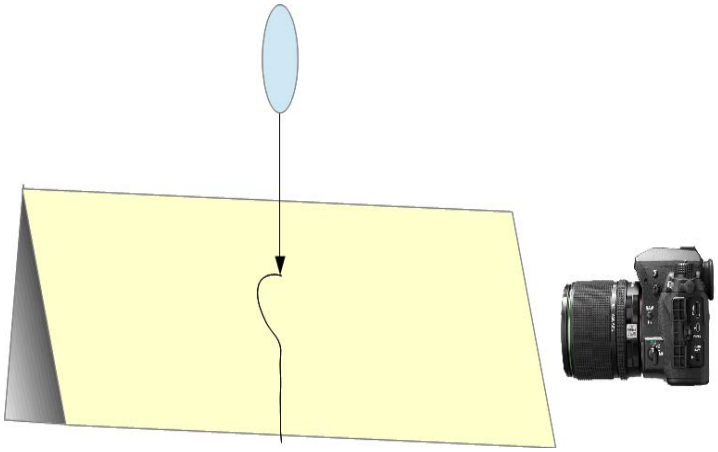

Figure 1. Abstract of Setup

Physics

The fluid phenomenon is known as the "Kaye Effect", which was discovered by Alan Kaye in 1963. Mr. Kaye observed it in organic liquids, but has since been observed in all shear-thinning fluids. Most fluids maintain a constant ratio of shear force to resistance. A shear thinning fluid will provide more resistance at first, but once it starts moving, the resistance will diminish. The best known shear-thinning fluid in America is catsup; the reader should be familiar with the experience of going from no catsup to too much catsup in an instant. The Kaye effect can be observed when the shear-thinning fluid strikes an angled surface already coated with the fluid. This can occur even in a pile of the same fluid. As a common stream only lasts about 300 milliseconds[3], it is difficult to detect with the human eye.

The initial setup had the soap stream falling about 50 centimeters before striking the sloped surface. The final run was completed with the spout only about 30 centimeters above

impact. Lowering the height provided a slower impact velocity and a wider stream. The lower height proved to be a much better setup to capture the phenomenon.

The Image

Taken with a Pentax K-5, the original JPEG image was edited with the GIMP editing program, the artist used the PNG images to export the file data. The preserved field of view is approximately 2 inches by 8 inches wide.

Table 2: Camera and Original Image Data

Camera:	Pentax K-5
Lens:	SMC Pentax-DA L 18-55 II
Focal Length:	55 mm
F-stop:	f/7.1
Exposure:	1/100 sec.
ISO Speed:	ISO-400

Width:	4928 pixels
Height:	3264 pixels
Horizontal resolution:	300 dpi
Vertical Resolution:	300 dpi
Bit Depth:	24
Color Representation:	sRGB

The photograph color was enhanced in GIMP using the color hue modulation, to change the image from white and yellow to blue. The single stream was replicated using the clone brush tool. The clone tool was used on the photo file, so the original dimensions were preserved.

Figure 3. Untouched image

Conclusion

I am very pleased with this image. It superbly displays the stream bounce. The focus captures the length of the jump and the colorization gives a much more inviting and familiar feel to the image. In the revealing of this image, there were several people disappointed that the image had been made through a digital replication of a single stream, rather than achieving a series of similar parallel uniformly bouncing streams; considering the finicky nature of the Kaye Effect, I would feel comfortable saying that achieving 6 uniform parallel simultaneous bounces would be impossible.

References

1. http://en.wikipedia.org/wiki/Sodium_laureth_sulfate
2. http://en.wikipedia.org/wiki/Cocamidopropyl_betaine
3. http://en.wikipedia.org/wiki/Kaye_effect
4. Ball, P, “Puzzle of leaping liquid Solved”, Nature: International weekly journal of science, 06 HYPERLINK "http://www.nature.com/news/2006/060403/full/news060403-